Visualizing risks in cancer communication

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Abstract:

Objective: Health websites are becoming important sources for cancer information. Lay users, patients and carers seek support for critical decisions, but they are prone to common biases when quantitative information is presented. Graphical representations of risk data can facilitate comprehension, and interactive visualizations are popular. This review summarizes the evidence on computer-supported graphs that present risk data and their effects on various measures.

Methods: The systematic literature search was conducted in several databases, including MEDLINE, EMBASE and CINAHL. Only studies with a controlled design were included. Relevant publications were carefully selected and critically appraised by two reviewers.

Results: Thirteen studies were included. Ten studies evaluated static graphs and three dynamic formats. Most decision scenarios were hypothetical. Static graphs could improve accuracy, comprehension, and behavioural intention. But the results were heterogeneous and inconsistent among the studies. Dynamic formats were not superior or even impaired performance compared to static formats.

Conclusions: Static graphs show promising but inconsistent results, while research on dynamic visualizations is scarce and must be interpreted cautiously due to methodical limitations.

Practice Implications: Well-designed and context-specific static graphs can support web-based cancer risk communication in particular populations. The application of dynamic formats cannot be recommended and needs further research.

Keywords: Visual aids, visualization, risk communication, Internet, medical decision-making, Neoplasms, Cancer

1. Introduction

1.1. Informed decision-making and cancer risk communication

Crucial medical decisions arise throughout the cancer continuum and are demanding. Each phase comes with specific challenges: In prevention, the risk of developing cancer may occur in the distant future, while the possible benefits and harms of upcoming treatments are imminent for cancer patients. A full understanding of all benefits, risks, uncertainties and alternative courses is the ideal to make an informed decision [1,2]. Besides the physical and psychosocial burden of the disease, individuals affected by cancer are prone to common interpretation problems and biases. When it comes to comprehension and interpretation of relevant quantitative information, distortions by framing effects, ambiguity aversion, ratio biases, and other kinds of cognitive biases can interfere [3–5]. Cancer patients and their carers must deal with uncertainty in its various conceptualizations: Uncertainty regarding future events, validity of evidence, and complexity of risk information and models, and uncertainty about the personal significance [6–8]. Furthermore, numeracy has a major influence on people's ability to process quantitative information and to interpret accurately medical data based on their risk knowledge and perception; consequent disadvantages are associated with low numeracy skills [9–13]. For example, the majority of respondents overestimate the benefits of breast cancer and prostate cancer screening programs, while they underestimate the harms [14,15].

These problems in medical risk communication are well known and have been tackled. Recommendations to overcome misinterpretation and to improve informed decision-making are available, e.g. the presentation of absolute rather than relative risk, natural frequencies rather than percentages, and others. One common strategy is the application of visual aids [2,16–20].

1.2. Decision aids, visual aids and visualizations in cancer communication

Visual aids have a long history in the communication of risks [21,22]. They can facilitate communication of statistical data and can enhance comprehension through various modes: By revealing patterns and trends, depicting proportions and part-to-whole relationship, supporting mental processing of information, catching attention with an attractive design, improving the transparency of risk information, attenuating common biases, and increasing accurate data recall [23–26]. Common graphical formats include icon arrays, bar charts, pie

charts, risk scales or ladders, and line graphs [27]. Besides risks of a disease, side effects of a therapy, and probabilities of survival, visual aids are also utilized to represent other data formats like patient-reported outcomes or the performance of health care providers [28–30].

Persons with low numeracy skills may benefit from visual aids, although this effect is not consistently observed [31–33]. Further graphic literacy plays a crucial role for the understanding of graphical displays [34–36]. Some reviews criticise the atheoretical approaches of most visual aid research [13,18,23]. Current research in medical decision-making and in visual aid research is focussing on dual-process models like the fuzzy-trace theory [34,37–39]. Albeit the common acceptance of visual data displays, the International Patient Decision Aid Standards (IPDAS) Collaboration and other authors emphasize cautious application because poorly designed and incorrect graphs can still bias risk communication [13,24].

Compared to visual aids, the evidence concerning decision aids is more robust. Regarding treatment and screening decisions in cancer and in non-malignant diseases, decision aids improve choice-made attributes, decision-making process attributes, patient-practitioner communication and result partly in a more satisfactory decision-making [40–42].

The IPDAS Collaboration also recommends interactive web-based formats, again emphasizing cautious employment because of the preliminary evidence [13]. Information visualizations are defined as interactive visual representation of data on computer-supported tools, thus they can be considered as a key component recommended by the IPDAS Collaboration [43]. They are supposed to improve communication of quantitative information and to provide insight into data [22,44]. Data visualizations are appraised as innovative Internet measures for cancer communication [45]. While visualizations are applied in a wide range of professional health communication contexts, scarce evidence and contradictory findings prevail in the communication to lay people [46–48].

1.3. Cancer information seeking in the Internet

Health professionals are the main source of information for cancer patients [49,50]. But in the last two decades, the importance of the Internet as a source of information has increased. About a third of information seekers, which are mostly young women, use

Internet information as an aid to decide whether to visit a health professional or not, and about a quarter for the preparation of an appointment [51]. Other motives include having easy access, gaining information, and asking for a second opinion and reassurance [52]. While the usage differs among countries, there is a steady and consistent rise in European countries [53,54].

About 40-50% of breast cancer and other oncology patients turn towards the Internet to find information, mostly those with a better education and higher income [55–58]. Cancer patients want accurate, comprehensible, comprehensive, and high quality information from online sources. Because trustworthiness regarding the quality of information is an issue, patients like to be referred to them by their physician or healthcare team [58,59]. Searching for and sharing cancer information from the Internet can improve doctor-patient communication, increase active decision-making and is associated with higher satisfaction [60,61]. But cancer patients may experience difficulties. About a third of women report information to be mistakable, intimidating or confusing [57].

Confusion can arise from misunderstanding of statistical information. The transformation of information and communication technologies offers unique opportunities for cancer communication. Risk information can be conveyed more specific and customized to different target groups, can be shared easier, and can engage participation [62]. Visual aids and visualizations can be beneficial tools to enhance understanding and transparency of quantitative cancer information [22].

This review summarizes the evidence regarding the efficacy or effectiveness of computer-supported visual aids and visualizations depicting quantitative information in cancer risk communication.

2. Methods

2.1. Search strategy

The search was carried out in August 2015. The search results were managed with EndNote X7. Literature databases were investigated via EBSCO and OVID search hosts. For the inclusion of databases, their descriptions were screened for relevance by the provided subject title and coverage lists. The EBSCO search included the following databases: Health

Source: Nursing/Academic Edition, Library, Information Science & Technology Abstracts, MEDLINE, Psychology and Behavioral Sciences Collection, PsycINFO, CINAHL and ERIC. The EMBASE database was searched via OVID. Additionally, the IEEE Xplore Digital Library was investigated. The finally included publications were evaluated for relevant references.

The initial search terms were derived from a prior thesis review, the German Cancer Society oncological database project and other relevant reviews [25,40,42,46]. Terms defining the condition of the target group (e.g. cancer, neoplasm), the intervention (e.g. web-based visual aid, information visualization) and the study design were combined. The search string integrated relevant subject headings and keyword search in the title and abstracts. Search strategies and subject headings were adapted for each database. The specified search strategies are provided in the supplementing material.

2.2. In- and exclusion criteria

The search was restricted to publications in English language, to human subjects, and peer-reviewed journals with controlled study design. No restrictions were made in regard to the date of the publications, and to the control condition or any specific outcomes. Publications were included if (a) the target groups were composed of patients or lay people; (b) the intervention was a computer-supported visual aid or visualization presenting quantitative cancer data; (c) the purpose of the intervention was cancer communication or decision support and (d) the publication provided any kind of quantitative evaluation.

2.3. Selection process

For the selection of publications by title and abstract or full text the www.covidence.org platform was utilized. This online tool supports the execution of systematic reviews. The first (JS) and second author (DM) selected publications independently according to the defined criteria. In case of insufficient information, the full text was obtained and analysed. When the intervention was not properly described, the authors were contacted for additional information. Discrepancies in the selection were solved by discussion. Most excluded publications concerned the intervention (e.g. complex interventions without a specific

evaluation, graphic not data-based or not computer-supported). Figure 1 depicts the selection process.

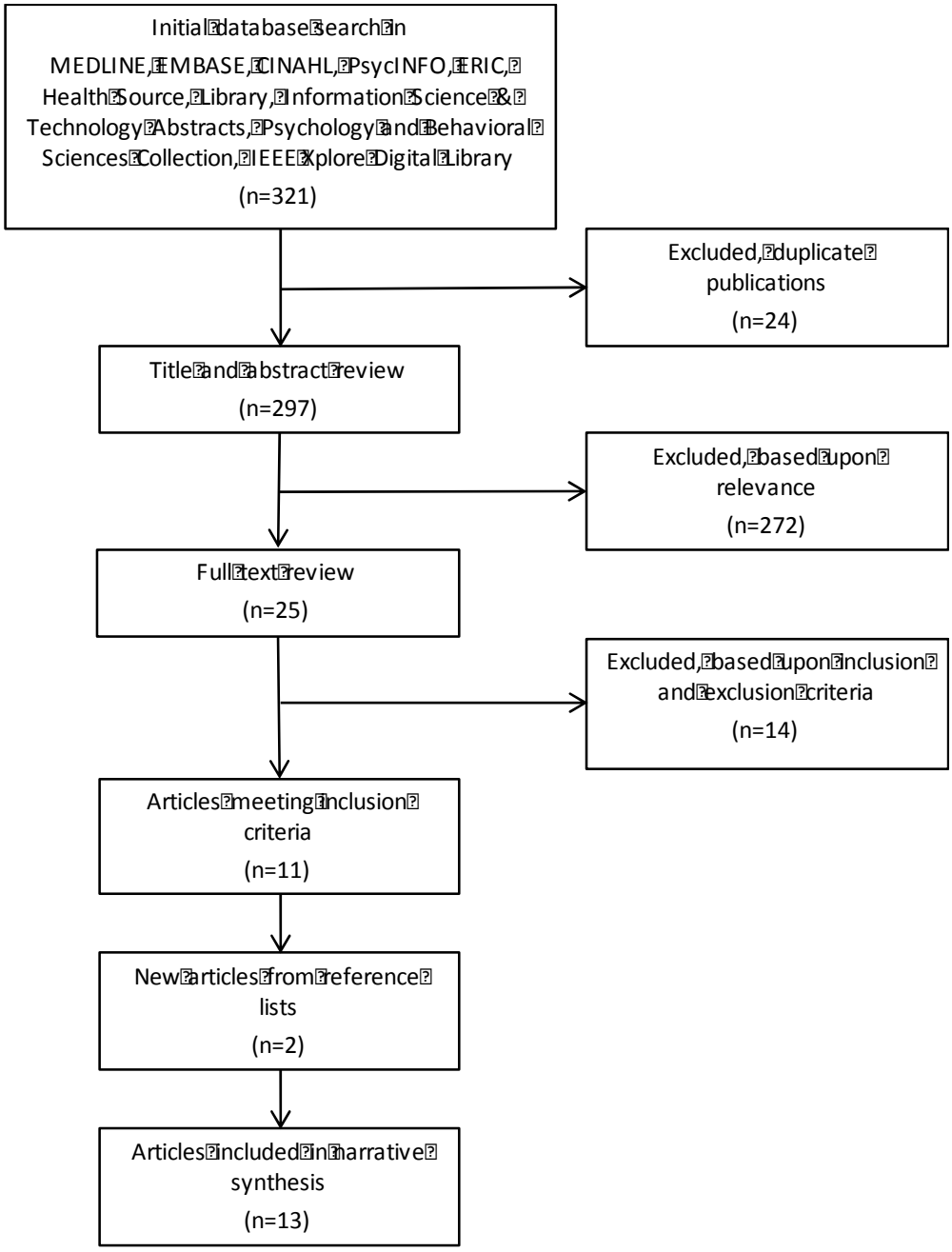

Figure 1: Flowchart of literature search and selection

2.4. Quality appraisal

The risk of bias was assessed according to the Cochrane risk of bias tool. The Cochrane Collaboration's tool for assessing risk of bias is comprised of six items to assess the risk of

selection, performance, detection, and reporting bias [76]. DR and JS carried out the quality assessment independently. Conflicting issues were solved by discussion.

2.5. Data extraction

The relevant publication data were extracted in a summary table. The pre-defined categories were first author, year of publication, sample size, age and gender, country, way of recruitment, type of cancer, description of intervention, description of control condition, outcome measures, summary of results, and risk of bias according to the Cochrane risk of bias tool. JS extracted the data, and DR controlled the data for accuracy. Because the designated outcome measures were foremost heterogeneous and inconsistent, some were grouped for summary purposes based on the underlying instrument items, where it seemed appropriate. For example, any measures of subjective assessment are labelled as rating.

Table 1: Summary of included studies about computer-supported visual aids in cancer communication

Author Year	Sample characteristics *Sample size* *Age (years)* *Gender (f)*	Country/ Recruitment	Type of cancer	Description of intervention	Description of control condition	Outcome measures	Summary of relevant results	Risk of bias				
								Selection 1	Selection 2	Detection	Attrition	Reporting
Cameron 2012 [63]	749 Mean 26.8 65%	AUS, NZ, UK, US, other University (staff & student)	Colon cancer	Icon arrays (humanoid, 5x20), static	Numeric text	Behavioral choice/intention (diet, gene test, pay), comprehension, efficacy beliefs, perceived risk	No effects	?	?	?	↓	↓
Cox 2010 [64]	522 ≥ 18 100%	USA Online panel	Cervical cancer (HPV prevention)	Icon arrays (stadium seats, absolute numbers), static Numeric text	No statistics	Behavioral choice/intention, comprehension, HPV-health beliefs/ severity of infection, vaccination vulnerability/ efficacy/ obstacles, need for internal consistency, numeracy	Behavioral choice/intention (vaccination) higher with icon arrays (53% vs. 41% vs. 37%, p=0.01) Interaction of intervention x rhetorical questions moderates comprehension (p=0.006)	↓	↓	?	↓	↓
Cox 2014 [65]	320 ≥ 30 100%	USA Online panel	Cervical cancer (HPV prevention)	Icon arrays (stadium seats, absolute numbers), static	Numeric text	Behavioral choice/intention, perceived comprehension, HPV-health beliefs/ severity of infection, vaccination safety / efficacy/ obstacles	Perceived comprehension higher (M=5.8 vs. 5.52, p=0.025) Interaction of intervention x anticipated regret questions moderates behavioural choice/intention (p=0.016)	↓	↓	?	↓	↓
Feldman-Stewart 2000 [66]	159 (36/72/12/12) - -	CA University (36 students) Hospital (96 patients)	Cancer, not specified	Icon arrays (ovals, 10x10, systematic vs. random), pie charts, bar charts (vertical vs. horizontal), all static	Numeric text	Accuracy (gross level-/ detailed-information), preferred format rating	Accuracy (gross-level) mostly higher with vertical bar chart Accuracy (detailed) higher with numeric format and systematic icon arrays Lowest accuracy scores with random icon arrays and pie charts	?	?	?	?	↓
Han 2011 [67]	375 (240/135) Mean 52/54 50%/ -	USA Online panel	Colorectal cancer	Bar charts (horizontal, strict edge=point estimate vs. blurred edge=confidence interval), static	Numeric text	Perceived risk, risk-related worries, perceived credibility, dispositional optimism, numeracy	No main effects Interaction of intervention x ambiguity (strict vs. blurred edges) moderates perceived risk (p=0.003) and risk-related worries (p=0.05); not confirmed in 2nd experiment	?	?	?	?	↓
Han 2012 [68]	225 Mean 53	USA Online panel	Colorectal cancer	Icon arrays (humanoid, 10x10, systematic vs.	Numeric text (non-random vs. random)	Perceived risk, risk-related worries, subjective uncertainty, dispositional	Subjective uncertainty higher with animated random icon arrays than with random text (M=2.7 vs. 2.1,	?	↓	?	?	↓

	46%			random), static/animated		optimism	p=0.02), but not with static icon arrays					
Waters 2007 [69]	4.248 Mean 42.5 68.9%	USA Online	Stomach or colon cancer	Bar charts (vertical), icon arrays (humanoid, 10x10), static	Numeric text	Behavioral choice/intention, numerical accuracy	Behavioral choice/intention highest with icon arrays, numbers only superior to bar graph (49.4% vs. 44.9% vs. 41.5%, p<0.01) Accuracy higher with both graphic formats, highest with icon arrays (68.2% vs. 64,3 vs. 61.5%, p<0.001)	↓	↓	?	↓	↓
Waters 2007 [70]	5.251 Mean 45.4 56.6%	USA Online	Stomach or colon cancer	Bar charts (vertical), icon arrays (asterisk, circles/ humanoid, 10x10), static	Numeric text	Behavioral choice/intention, numerical accuracy, subjective interpretation	No effects	↓	↓	?	↓	↓
Zikmund-Fisher 2008 [71]	1.619 Mean 54.5 100%	USA Online panel	Breast cancer	Icon arrays (rectangles, 10x10) static, 4 vs. 2 options Bar charts, static, 2 options	Bar chart (horizontal) 4 options (used by Adjuvant!)	Numerical accuracy, task time, rating, numeracy	2-option icon arrays superior and 4-option bar charts worst: Accuracy (77.2% vs. 51.1%, p<0.001) Task time (28 vs. 42 sec., p<0.001) Rating (M=7.67 vs. 6.88, p<0.001)	↓	↓	?	↓	↓
Zikmund-Fisher 2008 [72]	631 Mean 59 100%	USA Healthcare organizations	Breast cancer	Icon arrays (rectangles, 40x25) static	Numeric text	Perceived risk, gist knowledge, numeracy	No main effect Interaction of intervention x incremental risk (p<0.001)	?	?	?	↓	?
Zikmund-Fisher 2010 [73]	1.552 (838/714) Mean 54.7 100%	USA Online panel	Breast cancer	Icon arrays presenting only-survival-data (rectangles, 10x10) static	Icon arrays presenting multiple-outcome-data (rectangles, 10x10) static	Numerical accuracy, behavioural choice/intention, cognitive effort, rating, numeracy	Accuracy (1 of 3 questions) higher (62.7% vs. 49.7%, p<0.001) Treatment intention less likely (43.1% vs. 50.3%, p=0.04) Rating higher (M=7.98 vs. 7.68, p=0.04) 2nd experiment replicated intention and rating, but not accuracy results	?	?	?	↓	↓
Zikmund-Fisher 2011 [74]	2.426 Mean 49.1 50%	USA Online panel	Thyroid cancer	Icon arrays (rectangles, 10x10), interactive	Icon arrays (rectangles, 10x10), static	Choice accuracy, gist knowledge, burden (task time, break-off), numeracy	Higher dropout rate (23.1 vs. 3%, p<0.001) and more time spent (52 vs. 155 seconds, p<0.001) Choice accuracy lower (1 of 3 conditions; 51.6% vs. 43.8%, p=0.03)	?	?	?	↑	↓
Zikmund-Fisher 2012 [75]	4.198 Mean 49.1 53.8%	USA Online panel	Thyroid cancer	Icon arrays (rectangles, 10x10, systematic vs. random), animated	Icon arrays (rectangles, 10x10 systematic vs. random), static	Choice accuracy, gist knowledge, rating, numeracy	Choice accuracy and gist knowledge lower with animated, random icon arrays and high numeracy (multi-comparisons) Rating lower for random vs. systematic graphs (multi-	?	?	?	↑	↓

							comparisons)					

Selection 1 = Random sequence generation; Selection 2 = Allocation concealment**;** ? = risk unclear; ↑= risk high; ↓ = risk low

3. Results

3.1. Characteristics of the included studies

The publication dates range from 2000 to 2014. All studies were carried out in North America including one international study that additionally included participants from Australia, New Zealand and the United Kingdom [63]. The procedures were always web-based except for one study where the participants were invited for a computer-supported experiment [66]. This study was also exceptional because actual cancer patients were included. One other study applied a none-hypothetical scenario in a prevention context: Women from two health organizations with an elevated breast cancer risk were provided with information about a preventive medication [72]. The remaining publications utilized hypothetical scenarios concerning a range of cancer types and contexts.

In one experiment, students were recruited via University channels and in another also at a hospital [63,66]. Besides, all other participants were invited via websites or professional online panels. The participants were youngest in the University with a mean age of 26.8 years [63]. The mothers in two other trials with a preventive intention were prevailingly young in their thirties or early forties [64,65]. Otherwise, mean ages ranged from 42.5 to 59 years.

All studies applied a randomized, factorial experimental design, adding more than one factor in regard to the graphical design (e.g. systematic vs. random patterns) or to non-graphical factors like rhetorical questions. Only main effects and interactions regarding the research question are reported in this review.

The graphic format that was most often depicted was a grid of icon arrays. The icons shown ranged from simple ovals, rectangles to humanoid shapes or stadium seats. The icon pattern was mostly a symmetric 10 by 10 grid with icons ordered systematically or randomly. Other formats were bar charts and pie charts. Most icons and graphs were coloured. Almost all graphics were static, and only three studies investigated the effects of dynamic features [68,74,75]. Most control conditions were numbers presented in a text. In some cases, graphics were compared to each other by certain characteristics (e.g. static vs. interactive).

Two outcome domains dominated the evaluation measures: (1) The intention whether to take an action or behaviour like vaccination or a treatment, and (2) the accurate estimation or reproduction of a numerical value. Common participants were requested to rate the intervention. Other measures were more specific and included comprehension, credibility of information, uncertainty, and time to complete a certain task. Besides accuracy measures, most of the applied instruments were subjective. Numeracy as a covariate was assessed in six studies [67,71–75]. In summary, the applied measures were heterogeneous, mostly subjective, and specific to the decisional scenario.

3.2. Quality of the included studies

The results according to the Cochrane risk of bias tool are presented for each study in Table 1, and the risk of bias graph is located in the Annex, Figure 2. The item regarding the blinding of participants and personnel was assessed, but information was never reported in the publications, and thus the risk of bias could not be assessed. Although, blinding in these preponderant web-based studies occurs naturally with no face-to-face contact. Any expectations from the participants in regard to their allocation to the intervention are unlikely to affect outcomes. Hence, this item seems inappropriate in this research context, and is not presented in the overall bias appraisal. Blinding for outcome assessment was also never reported, but it may occur and is presented.

The included studies show a low risk of bias with respect to selective reporting and a low risk concerning attrition bias. High risk of bias occurred only in two studies in relation to incomplete data in one experimental arm [74,75]. In summary, unclear risk of bias due to insufficient information is dominant; low risk across most bias domains is moderate to high, while high risk of bias is only marginally present.

3.3. Static visual aids vs. numeric text format

Nine out of the 13 studies compared to one or more static graphical formats to numbers that were presented in a text. The study that was conducted by Feldman-Stewart and colleagues is comprised of four similar experiments [66]. The first experiment was a pilot test with psychology students, followed by experiments with cancer patients. All participants

were asked two kinds of questions: on a gross-level to decide which number or portion is bigger or smaller, and on a detailed level to estimate the difference between two numbers. The first two experiments included the most participants and showed similar results: Vertical bar charts led to the least error-prone and to the most accurate gross-level results, while pie charts led to the least accurate estimates. Numbers were superior in assessing differences accurately, and random icon arrays were worst. This was true for patients and students, although patients needed more time to complete the tasks. The following experiments included fewer patients and could replicate these results partly. There was no clear effect of colour or preferred format.

In two studies, Cox and colleagues investigated the effect of risk information formats on HPV vaccination as a measure of cervical cancer prevention. The risk information was significantly easier to comprehend with a coloured football stadium graphic [65]. This main effect was not present in the earlier study, but an interaction analysis revealed that the exclusion of another factor (rhetorical questions) led to the same positive results [64]. A significant main effect for more vaccination intentions was observed in the graphical group in the latter study, while the graph in the other study only revealed a moderating effect. Here, only participants, who were asked about future regrets concerning consequences of non-vaccination, benefited from the visual aid. In another study, an icon array display was more efficient in improving the treatment intentions for a preventive stomach cancer medication by diminishing the risk aversion concerning side effects [69]. To a lesser extent, this was also true for a vertical bar chart. The bar chart did not improve accuracy, but the icon array did. These results could not be reproduced with the same research questions and methods [70].

Zikmund-Fisher and colleagues demonstrated that gist knowledge was improved when information about side effects of a cancer medication was shown as an incremental risk [72]. But this effect was only present in an interaction analysis. Subsequently, the study conducted by Han and colleagues revealed a higher ambiguity tolerance among people with dispositional optimism [67]. In a later similar experiment, the static visual aid had no influence on the results [68]. In the only international study, the effect of a brief communication was tested, exhibiting information about diet, risk of colon cancer, and genetic tests [63]. There were no effects of the presented icon arrays in any of the applied measures.

3.4. Results on different static visual aid formats

In two online experiments different graphical formats from the Adjuvant! web-tool were compared [71,73]. Adjuvant! is a risk calculator that provides prognostic 10-year mortality data for early breast cancer patients, in regard to additional therapy after surgery, based on a set of common risk factors [77]. A bar chart illustrates these data in order to help professionals and patients to decide about the different adjuvant therapeutic options. In the first experiment, the original four bar charts, each presenting one treatment option, were compared to icon arrays utilizing the same data. Additionally, both graphic formats were reduced from four to two treatment choices [71]. The graphs that illustrated those two options have come up with significantly better results in regard to accuracy and task completion. The following experiment was based on these results and applied the same icon array – one depicting the four outcomes and the other presenting only cancer specific and overall mortality [73]. The icon array that exhibited only the mortality data was superior concerning the accuracy and rating, and the participants reported less treatment intentions. Because of a legend error, this study was replicated. In this study, the accuracy results slightly failed to reach a significant effect, while the other results were reproduced.

3.5. Animated visual aids vs. numeric text format

Besides the effects of static displays, the later online experiment by Han and colleagues also evaluated an animated visualization [68]. The animation highlighted humanoid icons in an array for every two seconds in another place as a means of representing randomness. Compared to a text that described the data and also included a random statement, the participants watching the animated graphic reported more subjective uncertainty, while effects on perceived risk or worries were not observed.

3.6. Interactive or animated visual aids vs. static visual aids

Only two studies that compared animated or interactive graphics to static data displays were found. The same principal investigator conducted both, and both applied a similar design and scenario. The frequency of side effects caused by focal beam therapy of thyroid cancer was presented in rectangular icon arrays. Both studies were the only ones with a high risk of

bias due to incomplete outcome data. In the first experiment, the interactive graph group was instructed to click a blank icon array until the correct frequency number is pictured [74]. The control group saw the complete, static array. There was a substantial higher attrition rate in the interactive graph group, and the dropout mainly occurred during the interactive task. But this phenomenon could not further be analysed within the study design. Concerning one decision context, the results from the interactive group were significantly less accurate than from the static graph. In the second experiment, icon arrays – initially animated based on the three basic animations and subsequently scattered systematically or randomly – were tested against static displays [75]. Again, a further evaluation of dropouts was not possible due to the study design. As an overall result, there were no improvements by the animations, and rather worse knowledge and rating scores, especially in the combination of randomly scattered icons.

3.7. Summary of findings from included studies

Most of the included studies evaluated static graphs in comparison to numeric text without any interactive or animated features. Besides one series of experiments with cancer patients and one study targeting women with an elevated risk for breast cancer, only hypothetical scenarios were applied, mostly including non-affected online panel members. Icon arrays were the dominant graphical format, followed by bar charts.

Static graphs demonstrate some promising results on Behavioural intentions, comprehension, accuracy, and favourable ratings by participants [64–66,69,73,78]. In the remaining studies, no main effects or only moderating effects were observed, which are more difficult to interpret [63,67,70,72]. Factors that modified the outcomes were questions about anticipated regret, rhetorical questions, presentation of incremental risk, and less graphical information [64,72,78,79]. Surprisingly, when numeracy was added all throughout half of the studies as a covariate in the analysis, moderating effects were rarely seen [64,67,71–75].

Dynamic features in the three studies were either based on interactivity or animations [68,74,75]. Performance of the participants was partly less accurate compared to the static graphs, but with a high risk of incomplete outcome data. The risk of bias in the static graph studies was low in regard to reporting and attrition, but mostly it was not assessable with

respect to selection and detection bias. The presentation of randomness or ambiguity led to an elevated risk perception, worries, worse performance, and inferior ratings with static or dynamic graphs [66–68,75].

4. Discussion and Conclusion

4.1. Discussion

Compared to other systematic reviews about decision aids in general and specific to cancer, our findings are less robust and consistent. This can be attributed to the smaller number of studies. In the reviews by Stacey or Trikalinos and colleagues, the number of included studies range from 23 to 87 in oncology [40–42]. These meta-analyses consistently report improvements in knowledge scores, higher accurate risk perception, lower decisional conflicts, and more informed and value-congruent choices. This can be confirmed in some studies reviewed here. However, measures regarding informed choices were not applied in any study, even though an informed choice seems like a reasonable target in this context.

According to a review about visual aids, the outcome measures fall into three main categories: Measures targeting at knowledge and comprehension, instruments detecting a behavioural intention or change, and scales rating the acceptance of the graphics [80]. The applied instruments and findings in our review are heterogeneous. When compared to numeric text, static graphics demonstrated superior results in some measures, but not consistent among the studies. The most consistent results are the favourable ratings of the graphical interventions. But similar to former research, there is no evidence that the preferred format or attractiveness is consistently associated with superior performance [34,80,81].

One explanation for the heterogeneous results can be that most of the experiments were carried out in a naturalistic and uncontrolled environment, such as online panels or a websites. Therefore, most studies evaluated the effectiveness. One advantage of effectiveness studies is a high external validity, while the internal validity is limited, because the effects are un-witnessed. Ineffectiveness of an intervention can be real, or attributed to other factors like poor implementation, lack of acceptance, comprehension, and adherence [82]. This can, at least partially, be true for the reviewed studies. Comprehension problems may occur undetected, which may lead to biased results; in this review, this risk is especially

high concerning the dynamic graphs. According to the recommendations by the IPDAS Collaboration, thorough pilot testing, under controlled conditions, is required to reveal usability issues [13]. The only included study that was carried out under controlled conditions demonstrated equal accurate results with numbers and systematic ovals, and with vertical bar charts leading to the most accurate results concerning to gross level information [66]. Gaissmaier and colleagues performed a test on printed data presentation of bar graphs and icon arrays, proved superior comprehension, and recall in a controlled experiment with participants having a high graphical literacy [34]. Other reviews and studies on static, printed visual aids of statistical data support these findings [25,83,84].

Furthermore, only one of the reviewed studies included cancer patients, and another study applied a non-hypothetical scenario [66,72]. Making an actual medical decision poses peculiar demands, and it must often be made under strained and stressful conditions. Some researchers argue that the difference between hypothetical and naturalistic scenarios is so substantial that different phenomena are investigated [85]. The problem of speculative scenarios is also prevalent in other medical-decision making research [4]. Two decision aid reviews consequently excluded all hypothetical decision studies, and found moderate to high quality evidence for improvements in various measures [40,42]. Although, one experiment included here demonstrated comparable results of students and patients, except from a longer time to complete the tasks among patients [66]. Hypothetical decision-making may provide a good estimate about the efficacy of computer-supported visual aids, but the applicability of results to actual medical decisions is questionable [4,85].

The IPDAS Collaboration considers web-based interactive decision aids as key element for the communication of quantitative information, and interactive visualizations tools are becoming applicable, accessible, and easy-to-use [13,22]. In this review, only three studies evaluate the dynamic features for their data presentations, without any promising results [68,74,75]. Interactive and animated features were generally not superior, and on some scales, even led to inferior results compared to static graphs. But limitations must be noticed: Firstly, no prior usability testing was reported in these publications. High attrition rates and poor performance may result from comprehension and usability issues. Because no characteristics about the dropouts were available, it is difficult to draw firm conclusions. Ancker and colleagues applied a hypothetical non-cancer scenario, and performed a pre-test on their interactive graphics regarding usability [86]. Even though the interactive aid did not

improve risk feelings and estimates, attrition rates among the experimental arms were balanced.

Moreover, the mode of action for the interactive visualization seems unclear. In one study, Zikmund-Fisher suggests that active processing and better comprehension are supported by interactive features, but clicking on icons to reveal accurate frequencies did not show this effect [74]. In a paper-and-pencil-based experiment, active processing was stimulated by actual graph drawing or reflective questions [87]. Both stimuli increased the number of accurate frequency estimates. Okan and colleagues integrated reflective questions in an interactive icon array graph, representing the survival benefits of a hypothetical anti-cholesterol drug [81]. Depending on the graph literacy, the presentation of graph labels, and the format of the denominator, the reported numbers were significantly more accurate. Hence, the interactive stimulus in the reviewed experiments may not be adequate to motivate sufficient active processing, and additional reflective tasks or features are needed to improve cognitive performance.

Common relevant covariates were only partially assessed in the reviewed studies, namely numeracy and graphic literacy. Numeracy is an essential skill to interpret quantitative health-related information. More specifically, it is also described as health numeracy or statistical literacy, and visual aids are means to overcome low numeracy skills [12,25,88,89]. Only about half of the studies measured numeracy, and in these studies, interacting effects were rarely observed [67,71,71,73–75]. This may be attributed to the subjective instruments that were applied. Although subjective and objective numeracy are related, distinct constructs are measured. While subjective instruments are more acceptable than objective instruments, people may overestimate or underestimate their numeracy skills, which may lead to biased results [90]. Graph literacy can be another crucial factor to identify people, who can be the most suitable for graphic interventions [35,36]. Some studies have demonstrated that persons with high graph literacy—the ability to comprehend graphically presented information—benefit more from health graphs. But research on graph literacy has developed only recently [34,91,91].

Theoretical assumptions about how the actual visual aid supports information processing were not elaborated in any study. Some measures like gross and detailed accuracy or gist knowledge may implicitly point to an underlying dual process theory, but were not explicitly

discussed [66,74,75]. Therefore, the criticism of atheoretical approaches in visual aid research that is mentioned in earlier reviews still remains [13,18,23].

Some limitations of this review must be stated. Most of the studies that are included in this review evaluated static graphs. Assuming that static visual aids on a computer screen are largely processed similar to printed material, the restriction to computer-supported formats limits the number of included studies. Without these constraints, the results concerning static visual aids in cancer communication may have been more robust. Furthermore, one idea of this review was to find evidence about advanced visualization formats. Unfortunately, only very few controlled experiments about dynamic graphs could be found, and no firm conclusions can be drawn at this point. Other restrictions in the search methodology (e.g. no grey literature, English language) may have led to the exclusion of relevant material. The risk of publication bias can always occur in systematic reviews. Albeit, the findings are mixed, negative results are reported, and the risk of selective reporting was low. Therefore, a high risk for publication bias seems unlikely.

4.2. Conclusion

This has been the first review that systematically summarizes the results, and evaluates the quality of studies on computer-supported visual aids in cancer risk communication. In regard to static displays, computer-supported visual aids seem to work as well as printed ones. But the evidence is less robust compared to general decision aids in cancer, and should be confirmed by applying consistent measures in real-life decision-making. Bar charts and icon arrays are common formats and seem to work well in various contexts. The information design of visual aids should stick to the established approach of reducing complexity [92,93].

Research on interactive visualizations in cancer communication is still in its infancy. The term information visualization was not applied in the studies, although the graphics comply with common definitions. Until now, the aim of information visualizations, which is to gain insight, is not achieved in cancer communication; they may be rather confusing. If visualizations do not facilitate comprehension and support decision-making, they cannot be recommended at this point. But the few reviewed studies should be interpreted with caution. While promising theories about the cognitive processing of visual aids are evolving, their application in evaluation research is still insufficient.

4.3. Practice Implications

Well-designed, pre-tested and context-specific static visual aids can improve web-based cancer risk communication in particular populations. Icon arrays and bar charts are feasible and the design should be simple. The application of dynamic formats cannot be recommended and it needs further research. Future studies should take into account the following aspects: (a) there is a lack of research that targets the affected groups, and studies should include people in actual medical decision-making; (b) evaluation in a naturalistic, uncontrolled settings should be supported by pre-tests, and experiments under controlled conditions; (c) numeracy and graphic literacy are important co-factors and should be measured consistently to confirm, if visual aids can help to overcome misinterpretation due to low numeracy, and can identify populations that benefit the most; (d) informed choice is a reasonable aim and should be evaluated; (e) theories about graph comprehension and information processing should be integrated to demonstrate, such as why and when visual aids work.

Conflict of interest statement

The authors declare that they have no conflicts of interest.

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Appendix

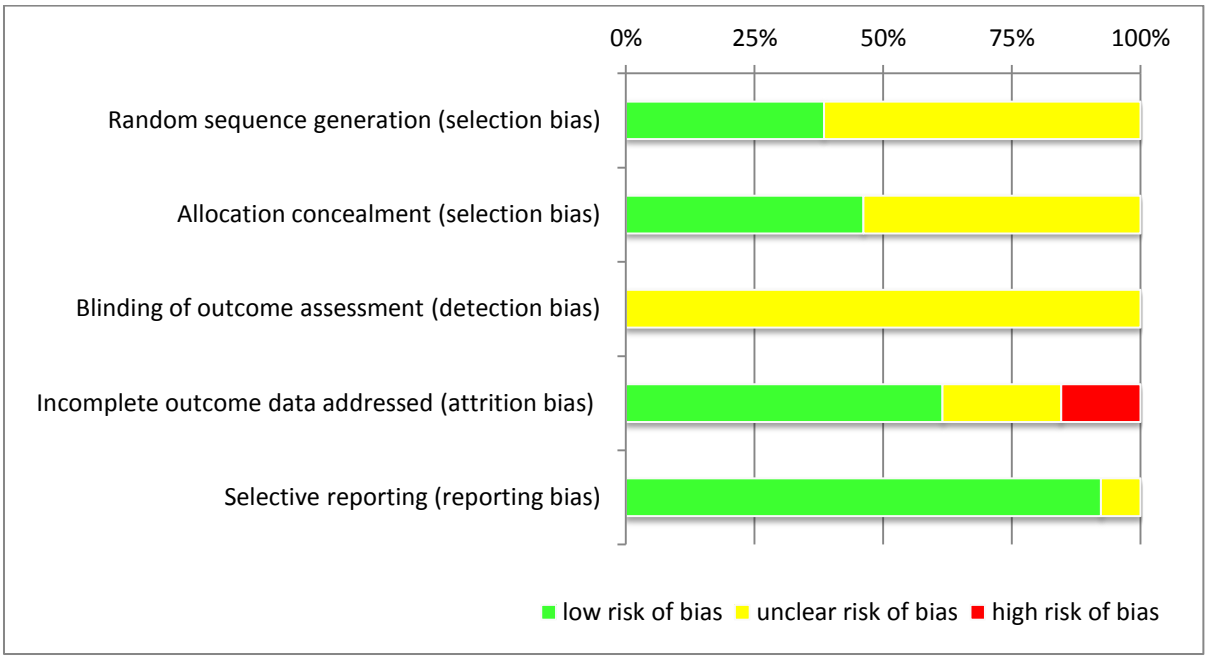

Figure 2: Risk of bias graph *(Colour print required)*

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Supplement

1. Search strategies

1.1. CINAHL 2015-08-15 (EBSCO)

Search ID#	**Search Terms**
S24	S17 AND S22
S23	S17 AND S22
S22	S18 OR S19 OR S20 OR S21
S21	TI control* OR AB control*
S20	TI random* OR AB random*
S19	PT randomized controlled trial
S18	PT clinical trial
S17	S4 AND S16
S16	S12 OR S15
S15	S13 AND S14
S14	TI (visual* OR graph*) OR AB (visual* OR graph*)
S13	SU (Decision Support Technique OR Decision Support System OR decision support systems, clinical OR Medical Informatics OR Computer Graphics OR Data Display OR Decision Making, Computer-Assisted OR Medical Illustration OR decision making, patient)
S12	S10 AND S11

S11	TI (web-based OR web based OR computer-supported OR computer supported OR internet* OR online OR interactiv*) OR AB (web-based OR web based OR computer-supported OR computer supported OR internet* OR online OR interactiv*)
S10	S5 OR S6 OR S7 OR S8 OR S9
S9	TI (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*) OR AB (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*)
S8	TI (interactiv* graph* OR interactiv* visuali* OR graph* displ*) OR AB (interactiv* graph* OR interactiv* visuali* OR graph* displ*)
S7	TI (information* visuali* OR information* graph* OR infovis OR info-vis) OR AB (information* visuali* OR information* graph* OR infovis OR info-vis)
S6	TI (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*) OR AB (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*)
S5	TI (data visuali* OR data graph* OR data displa* OR data represent*) OR AB (data visuali* OR data graph* OR data displa* OR data represent*)
S4	S1 OR S2 OR S3
S3	AB (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S2	TI (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S1	SU (neoplasms OR neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)

1.2. Health Source: Nursing/Academic Edition 2015-08-15 (EBSCO)

Search Terms	Search Options
S20	S4 AND S16 AND S17
S19	S4 AND S16 AND S17
S18	S4 AND S16 AND S17
S17	S10 OR S13
S16	S14 OR S15
S15	TI (control* trial*) OR AB (control* trial*)
S14	TI random* OR AB random*
S13	S11 AND S12
S12	TI (visual* OR graph*) OR AB (visual* OR graph*)
S11	SU (Decision Support Systems OR Decision Making OR Choice behavior)

S10	S5 OR S6 OR S7 OR S8 OR S9
S9	TI (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*) OR AB (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*)
S8	TI (interactiv* graph* OR interactiv* visuali* OR graph* displ*) OR AB (interactiv* graph* OR interactiv* visuali* OR graph* displ*)
S7	TI (information* visuali* OR information* graph* OR infovis OR info-vis) OR AB (information* visuali* OR information* graph* OR infovis OR info-vis)
S6	TI (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*) OR AB (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*)
S5	TI (data visuali* OR data graph* OR data displa* OR data represent*) OR AB (data visuali* OR data graph* OR data displa* OR data represent*)
S4	S1 OR S2 OR S3
S3	AB (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S2	TI (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S1	SU (neoplasms OR neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)

1.3. Library, Information Science & Technology Abstracts 2015-08-14 (EBSCO)

Search Terms	Search Options
S19	S4 AND S17
S18	S4 AND S17
S17	S12 OR S15 OR S16
S16	SU Computer Graphics
S15	S13 AND S14
S14	TI (visual* OR graph*) OR AB (visual* OR graph*)
S13	SU (Decision Making OR Decision Support System OR Medical Informatics)
S12	S10 AND S11
S11	TI (web-based OR web based OR computer-supported OR computer supported OR internet* OR online OR interactiv*) OR AB (web-based OR web based OR computer-supported OR computer supported OR internet* OR online OR interactiv*)
S10	S5 OR S6 OR S7 OR S8 OR S9
S9	TI (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*) OR AB (visual* uncertaint* OR visual* statistic* OR visual* aid* OR

	visual* analy* OR visual* present* OR visual* represent* OR visual displ*)
S8	TI (interactiv* graph* OR interactiv* visuali* OR graph* displ*) OR AB (interactiv* graph* OR interactiv* visuali* OR graph* displ*)
S7	TI (information* visuali* OR information* graph* OR infovis OR info-vis) OR AB (information* visuali* OR information* graph* OR infovis OR info-vis)
S6	TI (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*) OR AB (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*)
S5	TI (data visuali* OR data graph* OR data displa* OR data present* OR data represent*) OR AB (data visuali* OR data graph* OR data displa* OR data present* OR data represent*)
S4	S1 OR S2 OR S3
S3	AB (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S2	TI (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S1	SU (neoplasms OR neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)

1.4. MEDLINE 2015-08-15 (EBSCO)

Search Terms	Search Options
S25	S18 AND S23
S24	S18 AND S23
S23	S19 OR S20 OR S21 OR S22
S22	TI (control* AND trial*) OR AB (control* AND trial*)
S21	TI random* OR AB random*
S20	PT randomized controlled trial
S19	PT controlled clinical trial
S18	S4 AND S17
S17	S12 OR S15 OR S16
S16	SU (Computer Graphics OR Data Display OR Medical Illustration)
S15	S13 AND S14
S14	TI (visual* OR graph*) OR AB (visual* OR graph*)
S13	SU (Decision Support Technique OR Decision Support System OR Medical Informatics OR Decision Making, Computer-Assisted)
S12	S10 AND S11

S11	TI (web-based OR web based OR computer-supported OR computer supported OR internet* OR online OR interactiv*) OR AB (web-based OR web based OR computer-supported OR computer supported OR internet* OR online OR interactiv*)
S10	S5 OR S6 OR S7 OR S8 OR S9
S9	TI (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*) OR AB (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*)
S8	TI (interactiv* graph* OR interactiv* visuali* OR graph* displ*) OR AB (interactiv* graph* OR interactiv* visuali* OR graph* displ*)
S7	TI (information* visuali* OR information* graph* OR infovis OR info-vis) OR AB (information* visuali* OR information* graph* OR infovis OR info-vis)
S6	TI (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*) OR AB (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*)
S5	TI (data visuali* OR data graph* OR data displa* OR data represent*) OR AB (data visuali* OR data graph* OR data displa* OR data represent*)
S4	S1 OR S2 OR S3
S3	AB (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S2	TI (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S1	SU (neoplasms OR neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)

1.5. PsycInfo 2015-08-15 (EBSCO)

Search ID#	**Search Terms**
S22	S4 AND S16 AND S20
S21	S4 AND S16 AND S20
S20	S17 OR S18 OR S19
S19	TI trial* OR AB trial*
S18	TI control* OR AB control*
S17	TI random* OR AB random*
S16	S10 OR S15
S15	S13 OR S14
S14	S11 AND S12
S13	SU Graphical Displays

S12	TI (visual* OR graph*) OR AB (visual* OR graph*)
S11	SU (Decision Support Systems OR Decision Making OR Choice behavior)
S10	S5 OR S6 OR S7 OR S8 OR S9
S9	TI (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*) OR AB (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*)
S8	TI (interactiv* graph* OR interactiv* visuali* OR graph* displ*) OR AB (interactiv* graph* OR interactiv* visuali* OR graph* displ*)
S7	TI (information* visuali* OR information* graph* OR infovis OR info-vis) OR AB (information* visuali* OR information* graph* OR infovis OR info-vis)
S6	TI (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*) OR AB (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*)
S5	TI (data visuali* OR data graph* OR data displa* OR data represent*) OR AB (data visuali* OR data graph* OR data displa* OR data represent*)
S4	S1 OR S2 OR S3
S3	AB (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S2	TI (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S1	SU (neoplasms OR neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)

1.6. Psychology and Behavioral Sciences Collection 2015-08-14 (EBSCO)

Search ID#	**Search Terms**
S18	S4 AND S17
S17	S12 OR S15 OR S16
S16	SU (Computer Graphics OR Data Display OR Medical Illustration)
S15	S13 AND S14
S14	TI (visual* OR graph*) OR AB (visual* OR graph*)
S13	SU (Decision Making OR Decision Support System OR Medical Informatics)
S12	S10 AND S11
S11	TI (web-based OR web based OR computer-supported OR computer supported OR internet* OR online OR interactiv*) OR AB (web-based OR web based OR computer-supported OR computer supported OR internet* OR online OR interactiv*)
S10	S5 OR S6 OR S7 OR S8 OR S9

S9	TI (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*) OR AB (visual* uncertaint* OR visual* statistic* OR visual* aid* OR visual* analy* OR visual* present* OR visual* represent* OR visual displ*)
S8	TI (interactiv* graph* OR interactiv* visuali* OR graph* displ*) OR AB (interactiv* graph* OR interactiv* visuali* OR graph* displ*)
S7	TI (information* visuali* OR information* graph* OR infovis OR info-vis) OR AB (information* visuali* OR information* graph* OR infovis OR info-vis)
S6	TI (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*) OR AB (risk* visuali* OR risc* visuali* OR risk* displ* OR risk* displ* OR risc* displ* OR risk* graph* OR risc* graph*)
S5	TI (data visuali* OR data graph* OR data displa* OR data present* OR data represent*) OR AB (data visuali* OR data graph* OR data displa* OR data present* OR data represent*)
S4	S1 OR S2 OR S3
S3	AB (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S2	TI (neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)
S1	SU (neoplasms OR neoplas* OR cancer* OR oncolog* OR tum*r OR malign* OR carcino* OR sarcom*)

1.7. EMBASE 2015-08-15 (OVID)

# ▲	Searches
1	exp neoplasm/
2	malignanc*.ti. or malignanc*.ab.
3	oncolog*.ti. or oncolog*.ab.
4	neoplas*.ti. or neoplas*.ab.
5	tum*r.ti. or tum*r.ab.
6	cancer*.ti. or cancer*.ab.
7	carcino*.ti. or carcino*.ab.
8	sarcom*.ti. or sarcom*.ab.
9	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10	data visuali*.ti. or data visuali*.ab. or data graph*.ti. or data graph*.ab. or data displa*.ti. or data displa*.ab.
11	risk* visuali*.ti. or risk* visuali*.ab. or risk* graph*.ti. or risk* graph*.ab. or risk* displa*.ti. or risk* displa*.ab.
12	information* visuali*.ti. or information* visuali*.ab. or infovis.ti. or infovis.ab. or info-vis.ti. or info-vis.ab. or information* graph*.ti. or information* graph*.ab.
13	interactiv* graph*.ti. or interactiv* graph*.ab. or interactiv* visuali*.ti. or interactiv* visuali*.ab. or interactiv* displa*.ti. or interactiv* displa*.ab.
14	visual* uncertaint*.ti. or visual* uncertaint*.ab. or visual* statistic*.ti. or visual* statistic*.ab. or visual* analy*.ti. or visual* analy*.ab. or visual* aid*.ti. or visual* aid*.ab. or visual* represent*.ti. or visual*

represent*.ab. or visual* displ*.ti. or visual* displ*.ab.

15 10 or 11 or 12 or 13 or 14

16 exp medical illustration/

17 exp computer graphics/

18 exp visual information/

19 16 or 17 or 18

20 exp decision support system/

21 exp information processing/

22 exp medical informatics/

23 exp medical decision making/

24 20 or 21 or 22 or 23

25 graph*.ti. or graph*.ab. or visual*.ti. or visual*.ab.

26 24 and 25

27 15 or 19 or 26

28 randomized controlled trial/

29 controlled study/

30 randomization/

31 random*.ti. or random*.ab. or controll*.ti. or controll*.ab.

32 28 or 29 or 30 or 31

33 9 and 27 and 32

34 limit 33 to (human and english language and exclude medline journals)

1.8. IEEE Xplore Digital Library 2015-08-15

Search Query Details

3

((((((("Publication Title":trial) OR "Abstract":trial) OR "Publication Title":randomized) OR "Abstract":randomized) OR "Publication Title":controlled) OR "Abstract":controlled)

648908 Metadata Aug. 14, 2015 13:05 UTC Delete

2

((((((((("Document Title":visuali*) OR "Abstract":visuali*) OR "Document Title":infovis) OR "Abstract":infovis) OR "Document Title":visual aid) OR "Abstract":visual aid) OR "Document Title":data representation) OR "Abstract":data representation) OR "Document Title":risk graph) OR "Abstract":risk graph)

51520 Metadata Aug. 14, 2015 13:02 UTC Delete

1

((("MeSH Terms":neoplasms) OR "Document Title":neoplasm OR cancer*) OR "Abstract":neoplasm OR cancer*)

17257 Metadata Aug. 14, 2015 12:56 UTC

2. Excluded publications

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